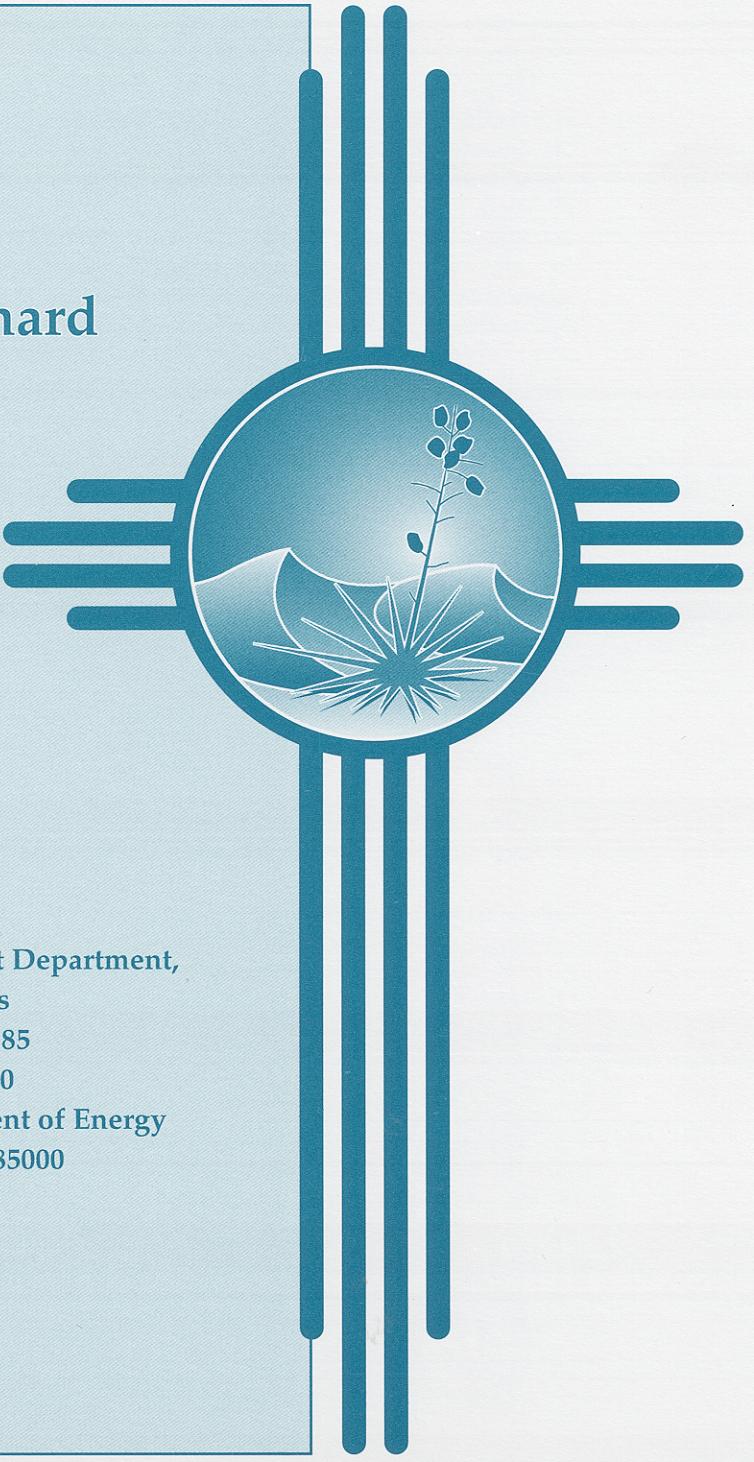
Milestones for Disposal of Radioactive Waste at the Waste Isolation Pilot Plant (WIPP) in the United States

Rob P. Rechard



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under contract DE-AC04-94AL85000

SAND98-0072 Revised
Unlimited Release
Printed March 2000
Supersedes SAND98-0072
dated April 1998

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Abstract

Six years (1983 to 1989) were spent constructing the Waste Isolation Pilot Plant (WIPP) in southern New Mexico for disposal of transuranic radioactive waste. However, not until 1999, 25 years after its identification as a potential deep geologic repository, did the WIPP receive its first shipment of waste. This report presents a concise history in tabular form of events leading up to its selection, including the development of regulatory criteria, major political conflicts, negotiated agreements, and technical milestones of the WIPP. In general, technical programs and engineering analysis of the WIPP before the mid 1980s were undertaken primarily (1) to develop general understanding of selected natural phenomena, (2) to satisfy needs for environmental impact statements, and (3) to satisfy negotiated agreements between the U.S. Department of Energy and the State of New Mexico. In the final segment of the project, federal compliance policy was developed and technical programs and engineering analysis evolved to assess the compliance of the WIPP with these specific regulations. During this ten-year period, four preliminary performance assessments, one compliance performance assessment, and one verification performance assessment were performed.

Preface

The milestones table for the Waste Isolation Pilot Plant (WIPP) Project was originally prepared as a section in the report, *An Introduction to the Mechanics of Performance Assessment Using Examples of Calculations Done for the Waste Isolation Pilot Plant Between 1990 and 1992*, SAND93-1378, by Rob P. Rechard. The milestones table, a particularly popular section, has been reproduced separately here and has been updated to include 1996 through 1999. As before, some text accompanies the milestone tables, but the emphasis remains on the tables because of their usefulness in providing a comprehensive but concise history of the WIPP. The usefulness of the milestones table is due in part to Anita Reiser, Darrell Munson, and Wendell Weart, all of Sandia National Laboratories, who helped with verification of information; C. Crawford of ASAP, Inc., who verified references; M. Minahan and J. Chapman, of Tech Reps, Inc., who edited the text; and S. K. Best, of Tech Reps, Inc., who placed the text in tables.

Contents

Acronyms/Initialisms

A/E – architect/engineering firm

AEA – *Atomic Energy Act*, either 1946 (Pub. L. 79-585–60 Stat. 755) or 1954 (Pub. L. 83-703–68 Stat. 919)

AEC – Atomic Energy Commission, the forerunner of the DOE, was formed in 1946 (August 1, 1946, 60 Stat. 755).

AG – Attorney General

AL – Albuquerque Operations Office, largest of several operations offices set up by DOE

ALARA – As low as reasonably achievable with costs and benefits taken into account; a basic policy of radiation protection initially proposed in 1948 and promulgated by NRC in 1975.

BRWM – Board of Radioactive Waste Management, a permanent board formed in 1968 in the National Research Council, the operating agency of the U.S. National Academy of Sciences (NAS)

BSPP – Bedded Salt Pilot Plant, initial name for WIPP in 1974

C&C – Consultation and Cooperation Agreement Between the State of New Mexico and the DOE

CAG – Compliance Application Guide, a non-binding guidance document developed by the EPA to supplement the WIPP implementing regulation, Title 40 CFR Part 191

CAMCON – Compliance Assessment Methodology CONtroller, computational system for assessing the performance of a disposal system (usually for nuclear wastes). When first developed in the early 1990s, this information management system provided for (1) the interfacing of individual computer codes of the WIPP PA modeling system, and (2) quality assurance of the computations.

CAO – Carlsbad Area Office, DOE office for managing WIPP Project, was formed in 1993 to replace the WIPP Project Integration Office (WPIO) that had been established in 1991, and the WIPP Project Office (WPO), which had been created in the 1980s and moved to Carlsbad, NM, in 1984.

CARD – Citizens Against Radioactive Dumping, New Mexico special interest group

CCA – Compliance Certification Application to the EPA to evaluate compliance with Title 40 CFR Part 191 of the Waste Isolation Pilot Plant; application coordinated by Westinghouse for the DOE with input from Sandia National Laboratories

CH-TRU – contact-handled Transuranic waste, packaged TRU waste whose external surface dose rate does not exceed 200 mrem per hour and can thus be directly handled by personnel

CFR – Code of Federal Regulations

DCCA – Draft Compliance Certification Application, prepared and sent to EPA in 1995

DHLW – Defense high-level waste, that is, high-level waste (HLW) that has been generated by the DOE in reprocessing spent nuclear fuel from experimental and military reactors. Because the possibility of commercial reprocessing was stopped under the Carter Administration in 1980 and never initiated thereafter, only about 72 MTHM equivalents from the West Valley Demonstration Project in New York or 0.75% is commercial HLW in the United States. Hence, the distinction between defense and commercial HLW is usually unimportant, except when highlighting the source of HLW or when discussing reprocessing and disposal plans for HLW in the United States prior to 1980.

DOE – U.S. Department of Energy, formed by *DOE Organization Act* (Pub. L. 95-91, 91 Stat. 565), which replaced the Energy Research and Development Agency (ERDA). ERDA was formed by the 1974 *Energy Reorganization Act* (Pub. L. 93-438) and replaced the Atomic Energy Commission (AEC), which was formed in 1946 (August 1, 1946, 60 Stat. 755).

DOI – U.S. Department of Interior

DOL – U.S. Department of Labor

DOT – U.S. Department of Transportation

EDF – Environmental Defense Fund, U.S. environmental special interest group

EEG – Environmental Evaluation Group, formed in 1978 by New Mexico from funds provided by the DOE to conduct independent technical evaluation of the WIPP. *The National Defense Authorization Act, Fiscal Year 1989*, Pub. L. 100-456, Section 1433 assigned administrative oversight of EEG to the New Mexico Institute of Mining and Technology.

EIS – Environmental Impact Statement, environmental documentation required by federal law (NEPA) (Pub. L. 91-190) for large, federally funded programs

EPA – U.S. Environmental Protection Agency, formed by Congress on December 2, 1970, in Reorganization Plan No. 3 of 1970 (5 U.S.C. 903; 40 CFR 1). In this act, Congress transferred to EPA the tasks of monitoring research, setting standards, and performing enforcement activities related to pollution abatement and control such that the environment could be considered as a single, interrelated system.

ERDA – Energy Research and Development Agency, a forerunner of the DOE, was formed in 1974 (Pub. L. 93-438).

FEPs – features, events (natural and anthropogenic phenomena of short duration), and processes (natural phenomena of long duration)

GAO – General Accounting Office, U.S. Congress

HLW – High-level (radioactive) waste, ". . . the highly radioactive material [fission products and some actinides,] resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations . . ." (NWPA, 1982, §2[12])[F26]. Although not used in this manner in this report, general articles regarding radioactive waste use the term high-level waste to imply any combination of spent nuclear fuel and HLW (and sometimes transuranic [TRU] waste) that requires disposal in a deep, geologic repository. 10 CFR 60, which was promulgated by the NRC prior to NWPA, also includes spent nuclear fuel in its definition of high-level waste.

HSWA – Hazardous and Solid Waste Amendments of 1984 (Pub. L. 98-616) (see also RCRA)

IAEA – International Atomic Energy Agency, Vienna, Austria, established in 1957 by General Assembly of the United Nations to foster research and development in the peaceful uses of nuclear energy

INEEL – Idaho National Engineering and Environmental Laboratory, a multiprogram laboratory in Idaho Falls, Idaho, furnishing engineering services and products on primarily nuclear energy and related technologies. The Idaho Chemical Processing Plant (ICPP) at the Idaho site processes highly enriched uranium fuel from spent nuclear fuel stored at the site. In addition to receiving spent nuclear fuel from throughout the DOE defense complex, it stores a large volume of TRU waste from Rocky Flats destined for the WIPP. Prior to 1970, it buried this TRU waste, but now stores it on the surface.

IRG – Interagency Review Group on Nuclear Waste Management. The Carter Administration formed this group on the recommendation of Secretary of Energy Schlesinger. The group consisted of the DOE and eight other agencies together with several entities within the Executive Branch, including the Council on Environmental Quality.

LANL – Los Alamos National Laboratory, a multiprogram laboratory in Los Alamos, NM, conducting research and development on all facets of nuclear weapon design and basic research in a variety of areas. A large volume of TRU waste stored on site is destined for the WIPP.

LEAF – Legal Environmental Assistance Foundation, U.S. environmental special interest group

LWA – *Waste Isolation Pilot Plant Land Withdrawal Act* (Pub. L. 102-579 – 106 Stat. 4777)

MED – Manhattan Engineering District of Army Corps of Engineers; assigned task of developing atomic bomb in 1942

MIT – Massachusetts Institute of Technology

MTHM – metric tons of heavy metal; regulatory mass unit in Title 40 CFR Part 191 where heavy metal is all the uranium, plutonium, and thorium *initially* placed in a nuclear power reactor

MRS – Monitored Retrievable Storage Facility for spent fuel from commercial power reactors, proposed in 1982 in NWPA and discussed in 1987 in NWPAA (see also RSSF)

NAS – National Academy of Sciences, a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research. The Academy was chartered by Congress in 1863 with the mandate to advise the federal government on scientific and technical matters.

NEFTRAN – network flow and transport computer program

NEPA – *National Environmental Policy Act of 1969*, federal law that sets environmental policy by requiring an environmental impact statement on all major federal project (Pub. L. No. 91-190, 83 Stat. 852)

NMED – New Mexico Environment Department.

NRC – Nuclear Regulatory Commission, formed by the 1974 *Energy Reorganization Act* (Pub. L. 93-438) from the – tomic Energy Commission

NRDC Natural Resources Defense Council, U.S. environmental special interest group

NWPA – *Nuclear Waste Policy Act of 1982* provides a national policy for the interim storage, monitored retrievable storage, and eventual disposal of radioactive waste.

NWPAA – *Nuclear Waste Policy Amendments Act of 1987*, amendments to the *Nuclear Waste Policy Act of 1982* specifying that only a repository site at Yucca Mountain was to be characterized by the DOE and placing less emphasis on the monitored retrievable storage option

ORNL – Oak Ridge National Laboratory, Y-12 Plant, Oak Ridge Reservation, Oak Ridge, TN. A large volume of TRU waste in storage is destined for the WIPP.

OTA – Office of Technology Assessment, U.S. Congress

PA – Performance assessment, the *process* of assessing whether a *system* meets a set of *performance criteria*. For the WIPP PA, the *process* is a stochastic simulation. The *system* is a deep geologic repository disposal system (in salt) for DOE TRU waste. The *performance criteria* are various long-term environmental metrics in U.S. government regulations (not short-term operational safety issues).

PRA – Probabilistic risk assessment, the process of assessing, through a stochastic simulation, the risks from a system. A PRA is identical to a performance assessment (PA) in the United States; however, the connotations of the two terms differ. A PRA usually connotes (a) a system composed solely of human-engineered components, and (b) performance criteria that include risk to health over a short time (e.g., human lifetime) relative to geologic time. A PA usually connotes a system composed of both natural and human-engineered components over geologic time. Because the time frame is different, many phenomena for a PRA can be termed events (short-term phenomena); because the components are all human engineered, measured failure rates of components are often available. The modeling tools in a PRA can include elaborate event and fault trees and can substitute empirical data for mechanistic models. For a WIPP PA, the event trees are simpler, fault trees are not used, and mechanistic models are used directly.

QA – quality assurance, all those planned and systemic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. Quality assurance for a product is ensuring that the product does what it is supposed to do to meet the specifications of the customer. The customer expectation, as related to a performance assessment, is that the analysis results present an adequate view (primarily from a legal standpoint) of the WIPP performance based on currently available data and information.

RCRA – *Resource Conservation and Recovery Act of 1976* (Pub. L. 94-580) and, as used herein, subsequent amendments (e.g., HSWA, *Hazardous and Solid Waste Amendments of 1984*, Pub. L. 98-616). RCRA establishes a procedure to track and control hazardous wastes from time of generation to disposal. Regulations in Title 40 CFR Parts 260-281 implement RCRA with respect to hazardous waste and hazardous waste treatment.

RH-TRU – remotely-handled transuranic waste, packaged TRU waste whose external surface dose rate exceeds 200 mrem per hour, but not greater than 1000 rem per hour, and thus must be handled remotely

RSSF – Retrievable Surface Storage Facility for spent nuclear fuel and high-level waste proposed in 1972 by the AEC

RWMC – Radioactive Waste Management Complex, a nuclear waste storage facility for the DOE complex built in 1952 at Idaho National Engineering and Environmental Laboratory (INEEL)

SA – Stipulated Agreement between the State of New Mexico and the DOE

SAB – Science Advisory Board, EPA

SAR – Safety Analysis Report

SNF – spent nuclear fuel, ". . . fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing" (NWPA, 1982)[F26]. Spent fuel can include intact and failed fuel assemblies, consolidated fuel rods, non-fuel components that are a part of a fuel assembly (such as neutron sources, instrumentation, and fuel channels). Although spent nuclear fuel has fissionable ^{235}U, it contains too many radionuclides (primarily short-lived) that adsorb neutrons from the fission process for it to be usefully left in the reactor. Because of spent nuclear fuel's high value, some countries choose to recycle it (recycling becomes more attractive after the short-lived fission products have decayed away). It is also designated separately from other high-level and transuranic wastes in the U.S. Environmental Protection Agency's standard on disposal of radioactive wastes, Title 40 CFR Part 191.

SNL – Sandia National Laboratories, a multiprogram laboratory located in Albuquerque, NM, and Livermore, CA. SNL is operated and managed for the DOE by the Sandia Corporation. From 1949 until October 1993, Sandia Corporation was a wholly owned subsidiary of AT&T. Sandia Corporation is currently a wholly owned subsidiary of Lockheed Martin Corporation.

SPDV – Site and preliminary design validation phase performed by Bechtel National, Inc.

SPM – System Prioritization Methodology, developed by Sandia in 1994 and 1995 as an attempt to combine probabilistic performance assessment results with decision theory to help prioritize experimental work conducted for the WIPP

SRP – Savannah River Plant Laboratory Production Reactors Defense Waste Processing Facility, located southeast of Augusta, Georgia. A large volume of TRU waste produced and stored on site is destined for the WIPP.

SWCF – Sandia WIPP Central Files

SWIFT II – Sandia waste isolation flow and transport computer code initially developed in the late 1970s and updated in the mid 1980s

SWRIC – Southwest Research and Information Center, New Mexico special interest group

TRU – TRansUranic, all elements of the periodic table having atomic numbers greater than 92

TRUPACT-I – Transuranic Package Transport, design I, designed to be a vented package in the same shape and size as standard shipping containers to facilitate shipment. The EEG objected to a vented container; so the package was completely redesigned (see TRUPACT-II)

TRUPACT-II – Transuranic Package Transport, design II, designed to be a pressurized hemispherical package for use on flatbed trucks

USGS – U.S. Geological Survey, Department of Interior (DOI)

WIPP – Waste Isolation Pilot Plant, a full-scale research and development repository for transuranic wastes near Carlsbad, NM. WIPP was authorized in 1979 (Pub. L. 96-164) for the management, storage, and eventual disposal of waste generated by DOE defense programs that is contaminated with transuranic radionuclides and some RCRA hazardous chemicals.

WPIO – WIPP Project Integration Office, formed in 1989, forerunner of the Carlsbad Area Office (CAO)

WPO – WIPP Project office, forerunner of the Carlsbad Area Office (CAO)

Milestones for Disposal of Radioactive Waste at the Waste Isolation Pilot Plant

New Mexico has a long history of involvement in nuclear phenomena: In 1942, the Manhattan Engineering District (MED) of the Army Corps of Engineers selected New Mexico for assembling the scientists, engineers, and technicians to develop the first atomic bomb and what was to become Los Alamos National Laboratory and Sandia National Laboratories (SNL). In 1945, the first atomic explosion occurred in the desert near Alamogordo, New Mexico. In 1961, the U.S. detonated a device to explore nonmilitary uses of nuclear explosives in bedded salt near Carlsbad, New Mexico (Gnome Project).[T8] Since 1973, New Mexico has been a potential disposal site for waste contaminated with transuranic (TRU) nuclear elements created during the production of nuclear weapons.[T7] A brief description of this latter aspect is presented below followed by a detailed tabulation of milestones of the Waste Isolation Pilot Plant (WIPP).

Early History of Nuclear Waste Disposal Related to the WIPP

Around 1944, the MED initially decided to bury solid nuclear waste in shallow trenches and augered holes at Los Alamos National Laboratory in New Mexico, and in railroad cars, trenches, and underground caissons at the Hanford Reservation in Washington. Liquid nuclear waste was stored in ponds at both sites. The Atomic Energy Commission (AEC), formed in 1946[F1] and the precursor to the Department of Energy (DOE), continued the practices of the MED. The AEC also constructed storage tanks in the late 1940s at Hanford and completed a nuclear waste storage complex at Idaho National Engineering and Environmental Laboratory (INEEL) in 1952.

From 1955 through the late 1960s, the AEC explored more permanent solutions for radioactive waste disposal in the United States, beginning with its request in 1955 that the National Academy of Sciences (NAS) examine the disposal issue.[D2] In 1957, the NAS reported that while various options and disposal sites were feasible, disposal in salt beds was the most promising method to explore.[T3] The NAS reaffirmed that recommendation in 1961. Frustration at the lack of a formal waste policy at AEC caused the NAS to strongly criticize AEC disposal practices in 1966.[N4, T7, T14]

In 1970, the Board of Radioactive Waste Management of the NAS concluded that bedded salt was satisfactory and was the safest choice then available for nuclear waste disposal.[T4, T16, T19] From 1961 through the early 1970s, Oak Ridge National Laboratory (ORNL) conducted radioactive-waste disposal experiments, most notably Project Salt Vault in an abandoned salt mine near Lyons, Kansas, from 1963 to 1967.[T10, T11]

In May 1969, the Rocky Flats Plant, built by the AEC in 1951 to machine plutonium for nuclear weapons, caught fire. Located only 26 km (16 mi) from Denver, Colorado, the fire attracted public attention. In its coverage, the press reported that the cleanup waste was eventually to be sent to Idaho.[T15] Idaho state officials voiced concerns that it was becoming the nation's nuclear waste disposal site by default. Hence, the AEC quickly moved to find a more suitable site and tentatively selected the Kansas mine as a repository in June 1970. At the same time, the AEC told Idaho Senator Church that the waste stored in Idaho would be removed by 1980 and sent to the salt mine.[D7] Later in 1970, a conceptual design was completed for a nuclear waste repository in salt.

Earlier in the year, in March 1970, the AEC had directed that thereafter TRU nuclear waste would be retrievably stored on the surface in Idaho and elsewhere rather than disposed of in trenches with low-level waste. In a related action, the AEC directed in 1971 that high-level waste (HLW) be solidified within five years, stored retrievably at all DOE facilities, and delivered to a federal repository within 10 years.[D6]

In the same year, a large number of drill holes and some solution mining were discovered at the proposed repository site near Lyons, Kansas.[T15] Soon after, Congress directed the AEC to stop work on the Lyons project until safety was certified.

Although the Lyons project was not officially abandoned until 1975, the AEC announced plans in May 1972 for a Retrievable Surface Storage Facility (RSSF).[D9] However, the recently formed U.S. Environmental Protection Agency (EPA) and anti-nuclear groups claimed the RSSF to be de facto permanent disposal, which prompted the AEC to continue searching for a more suitable disposal site.[T21–28]

Early Studies at the WIPP*

With the encouragement of local citizens and the tacit approval of Governor Bruce King, the AEC, ORNL, and the United States Geological Survey (USGS) recommended the extensive salt beds of southeastern New Mexico.[T29] After an initial study of existing information, a potential site near the edge of the basin was identified in 1973. The first large-scale field test was conducted in March 1974 when ORNL drilled wells AEC-7 and AEC-8.[T144] Also, in 1974, ORNL conducted the first scenario development and deterministic analysis for the proposed repository,[T7] although the project was suspended two months later.

In April 1975, SNL was chosen as the lead laboratory to (a) select and characterize,[T34] (b) develop a conceptual design,[T40] (c) draft an environmental impact statement (EIS),[D1] and (d) initiate scientific studies for the repository.[T39] After some site characterization, SNL recommended locating the WIPP site nearer the basin center where the stratigraphy was more predictable.[T15, T33, T34] (A minor repositioning of the disposal panels also occurred in 1982.) The newly positioned site would become the current WIPP repository, near Carlsbad, New Mexico.[D11]

National policy issues, court settlements, and negotiated agreements had a strong influence on the amount and type of scientific data collected during the early phase of the WIPP Project. The passage by Congress of the *National Environmental Policy Act of 1969*[F3] established a broad national policy requiring an EIS on large federally funded projects. The EIS process exerted its influence during the 1970s as the AEC, which later became the Energy Research and Development Agency (ERDA) and then the DOE,** continued investigations on bedded salt in general and, specifically, the salt deposit in New Mexico as a satisfactory medium for hosting a repository.

SNL's support of the EIS consisted of (among other things) detailed computer modeling of radioisotope escape through human intrusion and faulting, and the potential transport of radioisotopes through the aquifer overlying the WIPP to the Pecos River over a 250,000-year time frame (~10 half-lives of ^{239}Pu), followed by dose calculations to humans.[D1]

During 1978 and early 1979, and without consultation with the State of New Mexico, the mission of the WIPP oscillated between including and excluding commercial spent nuclear fuel (SNF) and HLW in the repository, in addition to TRU wastes.[D16, D17] Also, the new Carter administration required a fresh look at sites and options for nuclear waste disposal.[D18–20]

Because some of the examined options created uncertainty about DOE's intentions within the state and were counter to the ideas of some Congressional members, Congress firmly established the purpose of the WIPP Project as a research and development facility for storage and disposal of TRU waste only (i.e., HLW and commercial and defense SNF were excluded). Congress also specifically exempted regulation by the Nuclear Regulatory Commission (NRC) and thus by default granted self-regulation to the DOE.*** A national advisory group, the WIPP Panel, which was set up under the Board of Radioactive Waste Management of the NAS,[D11, T137] and an independent state-selected group, the

* Because the Waste Isolation Pilot Plant (WIPP) Project spans more than 25 years, more events and milestones have occurred than can easily be covered in a few pages; thus, the description is selective to those issues that do not require extensive explanations. However, the large influence of national and regional policy on the type and extent of scientific studies conducted at the site is still evident.

** The Atomic Energy Commission (AEC) was formed by the *Atomic Energy Act of 1946*.[F1] The Energy Research and Development Agency (ERDA) and the Nuclear Regulatory Commission (NRC) were formed by splitting the Atomic Energy Commission in the 1974 *Energy Reorganization Act*.[F10] ERDA became the Department of Energy (DOE) in 1977.[F16]

*** Although regulation by the Nuclear Regulatory Commission (NRC) would have been possible, the NRC had been established to regulate primarily commercial nuclear reactors and waste. Also, Congress did not favor NRC oversight of defense-related activities.

New Mexico Environmental Evaluation Group (EEG), were established on the initiative of the DOE to monitor its self-regulation.

After the final EIS[D1] was published in 1980 and a record of decision published in January 1981,[D24] the DOE proceeded to the preliminary design of the WIPP. Planning activities included a site and preliminary design validation (SPDV) phase, consisting of drilling two shafts in 1981 and 1982 and mining an experimental area. Full construction of the WIPP surface facility, an extensive underground experimental area, and one underground disposal panel began in 1983 after meeting the terms of the "Consultation and Cooperation Agreement" with the State of New Mexico and continued to completion over the next five years. Simultaneously with design and construction, SNL began fielding many in situ salt creep experiments to characterize the local disposal system.[T42, T68, T77] Although, from a practical standpoint, the predicted and measured values of creep were close, the measured salt creep was nevertheless about three times greater than the predicted values noted in 1985,[T81, T82] and so by 1989 an alternative mathematical expression for the creep phenomenon was developed.[T99]

In addition to developing a general understanding of selected natural phenomena as deemed prudent by SNL scientists (working with peers in waste management) and/or scientists on the WIPP Panel of the NAS,[D11, T137] many of the geotechnical experiments conducted during the 1980s were undertaken to satisfy agreements with the State of New Mexico. Specifically, in 1981 in response to a lawsuit, a "Stipulated Agreement" and the "Consultation and Cooperation Agreement" mentioned earlier were negotiated that defined the relationship of the WIPP Project with the State of New Mexico and listed required geotechnical experiments to be conducted primarily by SNL.[N8]

These requirements and early drafts of the EPA nuclear waste disposal regulation in Title 40 of the Code of Federal Regulations Part 191 (40 CFR 191) influenced the type of in situ experiments and activities initially planned at the WIPP. For example, when the WIPP-12 was deepened in 1981 as part of the negotiated settlement with the State of New Mexico, the project encountered a brine reservoir,[T64] which resulted in moving the disposal region ~1800 m to the south in 1982. By March 1983, SNL and the USGS had examined many of the geotechnical issues. For example, they had explored and dismissed the possibility of extensive dissolution disrupting the repository.[T69, T70]

The decision by Congress in 1987 to characterize only Yucca Mountain, Nevada, for the first commercial SNF and HLW repository[F35] caused the DOE to cancel many of the experiments being performed at the WIPP in support of a potential commercial repository elsewhere in bedded salt. The presence or absence of additional pockets of brine below the repository became of concern to the EEG in the early 1980s. Therefore, some studies were conducted to try to dismiss their presence.[T74] Though the studies strongly suggested brine pockets were not present below the waste rooms in the anhydrite layer in which other brine pockets had been found, the studies were unable to show unequivocally that brine pockets did not occur in deeper anhydrite layers in the Castile Formation. Long-term slow seepage of brine trapped in the salt into the repository became a topic of great interest in 1988,[N16] and the full Board of Radioactive Waste Management of the NAS examined the issue. Members of the NAS concluded that rapid salt creep combined with low permeability of the salt meant that the repository would be fairly well consolidated before much brine could enter the repository.[T90]

In preparation for the WIPP's planned opening by the end of the 1980s, SNL summarized past work and data, and performed numerous bounding calculations to support a Draft Supplemental EIS in 1989.[D34, T48] The summary identified gas generation—the gas being generated through anoxic corrosion of waste containers and degradation of organic material—as an important issue to study.[T48] This issue had been identified in the mid 1970s,[T47] but it was dismissed based on the assumption that high salt permeability values obtained from measurement in boreholes drilled prior to excavating the repository would allow any gas generated to dissipate without producing large pressures.

Studying gas generation became an important purpose of proposed tests using actual TRU waste within the repository during a monitored pilot phase, after better in situ measurements of the salt permeability within the excavations in the

mid 1980s suggested values three orders of magnitude less than those measured in the mid 1970s.[T90] However Congress stipulated in 1992 that the waste could be brought to the WIPP prior to demonstrating compliance only if the tests were scientifically necessary. Although the tests would have been potentially reassuring as a demonstration, the monitored pilot phase was not considered a scientific necessity.

Therefore, in October 1993, the NAS recommended[T124] to eliminate the tests with actual waste at the WIPP (pilot phase) and to perform additional experiments in laboratories.[D38] Without a pilot phase, the DOE decided to accelerate to the compliance phase for the WIPP and closed the in situ experimental area in October 1995.

Compliance Setting for the WIPP

A major task of the WIPP Project, which was initiated about 1986, was developing evidence of compliance. The promulgation of 40 CFR 191 in 1985 established the primary probabilistic regulation with which the WIPP would have to comply. However, a legal ruling in 1984[F30] and regulations in 1986 and 1987[D31] resulted in defining as much as 60% of the waste destined for the WIPP as chemically hazardous. This legal ruling established another set of regulations that the WIPP also had to comply with—those for hazardous waste (40 CFR 260-270 and analogous New Mexico regulations) promulgated in response to the *Resource Conservation and Recovery Act* (RCRA).[F13]

In 1992, Congress defined the process by which the WIPP compliance would be evaluated, transferred ownership of the WIPP site to the DOE, and designated the EPA (rather than the DOE) as the regulator of the WIPP (*Waste Isolation Pilot Plant Land Withdrawal Act*[F45]). This act officially marked the transition from the construction and disposal-system-characterization phase to the compliance and testing phases. However, these latter phases had begun informally in 1985 and 1986 when the EPA issued 40 CFR 191[F17] and its interpretation of mixed hazardous waste, and in 1989 when SNL first assessed performance using the EPA standard.[T110, T111]

Finally, in 1996, the EPA promulgated 40 CFR 194, a regulation to implement its 40 CFR 191 standard, which imposed several new interpretations, such as expanded human intrusion activities (specifically, potash mining), and requirements, such as peer review on waste characterization, engineered and natural barriers, and conceptual models.[F53] Also in 1996, Congress removed one of the RCRA land disposal requirements (i.e., seeking a no-migration variance), which required calculations similar to those for 40 CFR 191.[F54]

Development of Methodology for Assessing Compliance of the WIPP

The history of assessing performance of a geologic disposal system began formally in 1976 when the ERDA funded two conferences to bring engineers and geologists together to explore the modeling of geologic disposal systems. By 1977, demands for permanent solutions to nuclear waste provided an impetus for President Gerald Ford to request the EPA to more vigorously pursue applicable standards for proposed waste repositories.[D12, D13]

During the EPA's development of 40 CFR 191 in the late 1970s and early 1980s, analysts at SNL were advocates for a thorough approach in evaluating modeling uncertainty (caused by various parameters in models of the exposure pathways and the uncertainty about the various pathways) as a way to gain insight about the behavior of a geologic waste repository. For example, an analysis that SNL had conducted for the EIS had relied heavily on mathematical modeling.

SNL's position on this matter had developed indirectly from participation by a few Sandians on the 60-member team for the Nuclear Reactor Safety Study[F12] and Sandia's direct involvement on several subsequent reactor accident studies for the NRC. In addition, SNL's advocacy for a probabilistic approach was influenced by its use of the approach in evaluating the reliability of weapons systems and also by the growing acceptance externally for evaluating technological risks.

During this period, the term performance assessment (PA) was adopted internationally to

describe the process of evaluating whether a geologic disposal system complied with the regulatory criteria—criteria that were probabilistic in the United States, thus making the assessment identical to probabilistic risk assessments (PRA) for nuclear reactors.

Performance assessments of systems for the disposal of radioactive wastes nevertheless differed from most simulations used by federal agencies to explore policy options in two significant and related ways. First, in contrast with simulations for policy analysis, the EPA chose to use the PA results for the WIPP ultimately to test compliance of a real system with an existing environmental standard, not merely to gain insight into the behavior of the system. Second, the fact that part of the disposal system was geologic created several differences with some other types of risk assessments. For instance, the geologic portion of the disposal system introduced the necessity to characterize rather than design. Furthermore, geologic components of a waste disposal system are subject to natural processes over geologic time with no discrete failure points; hence, computer-implemented phenomenological models were needed in order to include geologic processes.

In August 1986, SNL accepted DOE's formal request to take responsibility for showing compliance of the WIPP with 40 CFR 191.[D29, D30] To gain proficiency and also to enable the project to better adapt efforts to collect information on important processes, SNL conducted four preliminary performance assessments from 1989 through 1992, each one building upon the other.[T110, T111, T116, T117, T121, T125] The use of mathematical models and the general long-term flow path for radioisotope release was similar to the initial EIS, but the simulations were stochastic and numerous complexities were added, such as human intrusion causing radioisotope releases from drill cuttings. Hence, between January 1988 and December 1991, a significant effort was expended in developing a computational modeling system, CAMCON.[T31, T91, T92, T115] Furthermore, vast numbers of records and documents were produced to ensure that the reasoning behind choices for data and models was traceable and repeatable.

In October 1996, the performance assessment for the Compliance Certification Application (CCA) was submitted to the EPA showing compliance with 40 CFR 191.[T135, T136] While not responsible for evaluating compliance, the NAS also issued a report in October that noted the excellent features of the WIPP site for containing nuclear waste.[T137, T138] These same conclusions were echoed in the 84,000-page second Supplemental EIS issued in November.[D43]

Between 1995 and 1997, the EPA and its contractors evaluated the CCA and supporting documentation.[F55] The Conceptual Model Peer Review Group (formed in response to requirements in 40 CFR 194) concluded in early 1997 that 22 of the 24 conceptual models were adequate. The panel thought that, though conservative, the model for spallings (particulates carried to the surface by pressurized gas and/or brine during a hypothetical drilling intrusion in the repository at a future time) lacked sufficient realism; hence, the panel required the model to be redeveloped. The panel also thought the description of the behavior of the magnesium oxide (MgO) backfill needed improvement. During the next few months, more detailed calculations of the spalling phenomenon were run to demonstrate the conservatism of the current model and DOE's commitment to develop a more realistic model before the next certification in five years.[T140] Also, additional information was provided on the behavior of the MgO backfill such that the Conceptual Model Peer Review Group concluded in an April meeting that these two modeling issues had been resolved. In addition, under the direction of the EPA, the PA calculations were rerun by SNL during the spring and summer, using EPA-selected values and distributions for 26 parameters to help bolster EPA confidence in the results.

Finally, in October 1997, the EPA published a draft rule proposing to approve the WIPP.[F57, F58] In May 1998, the EPA issued certification.[F59] In March 1999, Judge Penn lifted his injunction associated with a 1992 lawsuit by the State of New Mexico, and four days later the WIPP received its first shipment of non-RCRA waste.[T142, T143]

Summary

The opening of the Waste Isolation Pilot Plant on March 26, 1999, was the culmination of a regulatory assessment process that had taken 25

years. National policy issues, negotiated agreements, and court settlements during the first 15 years of the project had a strong influence on the amount and type of scientific data collected up to this point. Assessment activities before the mid 1980s were undertaken primarily (1) to satisfy needs for environmental impact statements, (2) to satisfy negotiated agreements with the State of New Mexico, or (3) to develop general understanding of selected natural phenomena associated with nuclear waste disposal.

In the last 10 years, federal compliance policy and actual regulations were sketched out, and continued to evolve until 1996. During this period, stochastic simulations were introduced as a tool for the assessment of the WIPP's performance, and four preliminary performance assessments, one compliance performance assessment, and one verification performance assessment were performed.

Detailed Tabulation of WIPP Milestones

In the following tabulation of WIPP milestones, the history of the WIPP is divided into four main categories. One category highlights technical milestones, and three categories highlight the major political events that have influenced the WIPP Project, as briefly summarized above. Noteworthy events from all four categories are also shown schematically. The tabulation also indicates two temporal categories of the WIPP Project—one used officially by the DOE for the project as a whole and one used informally by SNL to describe its various activities.

Milestones for Disposal of Radioactive Waste in the United States

Time Line	Noteworthy Events	Technical Milestones Related to the WIPP	U.S. President and DOE: Directives and Decisions	Federal Legislation, Judicial Decisions, and Regulatory Requirements Related to Nuclear Waste Disposal	Legal Challenges and New Mexico, National, and World Issues
1942	 **1942** LANL site chosen	● **1942** - All types of waste initially dumped in canyons at Los Alamos National Laboratory (LANL). [T1]	★ **1942** - Manhattan Engineering District (MED) Corps of Engineers selects site for LANL to develop a nuclear bomb.		Miles Admin.
1943	**1943** MED's 1st waste decision 	● **1943 -** Plutonium operations commence and disposal of nuclear waste begins on site at Oak Ridge National Lab (ORNL) in trenches and Clinch River. [T1] Water has saturated the bottoms of some trenches, and migration of radioisotopes has been observed.	★ **1943** - MED's earliest decision on managing waste: store high-level waste (HLW) as liquids in tanks and bury other waste (solid or liquid) in trenches. [D1]		Dempsey Administration
1944		● **1944 -** Disposal of nuclear waste begins on site at LANL (using trenches, ponds, augered holes) and Hanford Reservation (using railroad cars, trenches, ponds, tanks, underground caissons). [T2]	Roosevelt Administration		
1945	**1945** Atomic test in NM 	★ **1945** - Atomic bomb exploded at Trinity Site near Alamogordo, NM.			
1946			● **1946** - Atomic Energy Commission (AEC) Chairman: Lilienthal (Director of Tennessee Valley Authority)	● **1946** - Atomic Energy Act (AEA) of 1946 [F1]: - creates AEC - establishes government monopoly on atomic weapons and nuclear material	Mabry Admin.
1949			● **1949** - Truman asks AT&T to manage the recently formed Sandia Laboratory.		
1951			Truman Administration		
1952		● **1952** - Idaho National Engineering and Environmental Lab (INEEL) completes Radioactive Waste Management Complex (RWMC) for storing and burying waste; migration of radioisotopes downward into the alluvium has been observed.			Mechem Administration
1953		● **1953** - Savannah River Plant (SRP) begins waste storage and disposal on site at "Old Burial Ground"; water in trenches from precipitation has caused migration of radionuclides.	● **1953 -** AEC Chairman: Strauss		
		● **1954 -** Rocky Flats Plant near Denver, CO, begins shipping transuranic (TRU) waste to INEEL for disposal at RWMC.		● **1954** - AEA of 1954 [F2] seeks peaceful uses of atomic energy, thus allows regulated private atomic energy development.	
1955			● **1955 -** AEC asks National Academy of Sciences (NAS) to examine issue of permanent disposal of radioactive wastes. [D2]		Simms' Admin.
1957	**1957** NAS recommends exploring waste disposal in salt beds 	★ **1957** - NAS recommends radioisotope waste disposal in salt as most promising method. [T3] ORNL begins research in salt (1957-61). [T4] **May:** Rocky Flats Plant catches fire but kept secret. [T5]	● **1957 -** Plowshare program starts to look at peaceful uses of nuclear explosives. [D3]	Eisenhower Administration	Mechem Admin.
1959		● **1959** - NAS commission on oceanography reports on coastal disposal of low-level radioactive waste. [T6]			Burroughs Admin.
1960					

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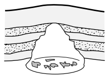
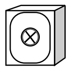
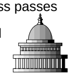
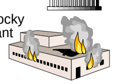
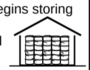
1961	**1961** Gnome test 	★ **1961 - Dec:** NAS reaffirms use of New Mexico salt beds for disposal.[T7] US Geological Survey (USGS) evaluates stratigraphy and AEC mines into Salado Fm. at Gnome site near Carlsbad, NM, for Gnome test as part of Plowshare program.[T8]	● **1961 -** AEC Chairman: Seaborg (co-discoverer of Pu) Kennedy Administration		Mechem Admin.
1962		● **1962 -** USGS reports on domestic salt deposits suitable for waste disposal; the Permian Basin in parts of NM, KS, TX, and OK is one area identified.[T9]			Bolack Admin.
1963	**1963** ORNL Project Salt Vault 	★ **1963 -** ORNL begins Project Salt Vault, a large-scale field test in which irradiated fuel elements and electric heaters are placed in an existing salt mine at Lyons, KS; up to 1967, the tests primarily study near-field effects.[T10, T11] INEEL adopts oxidation of liquid HLW to form solid grains ("calcine") for storing HLW.[T12, T13]	Johnson Administration		Campbell Administration
1965		● **1965 -** Savannah River Plant (SRP) begins disposing TRU waste in trenches on site.			
1966		● **1966 -** NAS reaffirms use of salt beds for disposal and strongly criticizes current disposal practices.[T7, T14, T15]			● **1966 - Jan:** B52 collides with refueling tanker at 30,500 ft.; three nuclear weapons crash into Spanish soil; fourth weapon parachutes into ocean.[N1, N2] Question raised as to how to define plutonium-contaminated soil (TRU waste). AEC later defined TRU waste in 1970.
1967					
1968		● **1968 -** Committee on Radioactive Waste Management established by NAS, later permanent "Board" (BRWM);[T14, T16] first task is to reevaluate the use of bedded salt.	● **1968 -** AEC asks NAS to revisit the issue of nuclear waste disposal.[D4] At request of Congress, General Accounting Office (GAO) audits AEC waste management practices and finds faults with records and management. AEC forms task force to address criticisms.[D5]		
1969	**1969** Congress passes National Environmental Policy Act (NEPA)  **1969** Rocky Flats Plant catches fire 	★ **1969 - May:** Rocky Flats Plant catches fire and cleanup waste sent to Idaho for disposal at RWMC; event focuses public attention on AEC nuclear waste problems.[T17] International Atomic Energy Agency (IAEA) forms advisory committee to categorize nuclear waste; Alpha-contaminated waste one category defined.[T18]	Nixon Administration	★ **1969 - Dec:** Congress passes National Environmental Policy Act (NEPA)[F3]: - requires federal agencies to consider environmental consequences of any major action through environmental impact statement (EIS) - first US environmental law to be applied to the Waste Isolation Pilot Plant (WIPP) Public comment provides avenue for groups to push for stringent regulations for nuclear facilities.	Cargo Administration
1970	**1970** NAS concludes bedded salt disposal safest choice now available   **1970** Lyons site selected for geologic repository **1970** Congress forms EPA	★ **1970 -** Conceptual design completed for HLW repository in salt. **Nov:** BRWM of NAS issues report concluding bedded salt satisfactory and safest choice now available for nuclear waste disposal.[T19]	★ **1970 - Mar:** AEC Chairman: Schlesinger. AEC directs TRU waste be stored retrievably at all DOE facilities rather than disposed with low-level waste.[D6] **Jun:** AEC tells Sen. Church that the waste stored at INEEL will be removed by 1980 and sent to salt mine.[D7] AEC tentatively selects mine in Lyons, KS, as repository.[D8]	★ **1970 -** Congress forms Environmental Protection Agency (EPA) and transfers to it research, monitoring, standard setting, and enforcement activities related to environment.[F4, F5] AEC conservatively bounds TRU waste as waste contaminated with transuranic radioisotopes with activity greater than 10 nCi/g.[F6]	
1971	**1970** AEC begins storing TRU waste above ground 	● **1971 -** Many drill holes and some solution mining discovered at Lyons, KS.[T15] USGS tests permeability of strata around Gnome site (Plowshare program) for closure studies by AEC.[T20]	● **1971 -** AEC states all commercially generated HLW must be solidified within 5 yr and delivered to a federal repository within10 yr.[D6]	● **1971 -** Congress directs AEC to stop Lyons project until safety is certified. Appeals court requires AEC to look at all environmental impacts in EIS.[F7]	● **1971 -** Attorney General (AG): Norvell. NM Environmental Improvement Act[N3] creates state environmental agency. King Admin.

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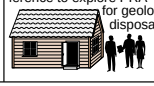
Milestones for Disposal of Radioactive Waste in the United States

Time Line	Noteworthy Events	Technical Milestones Related to the WIPP	U.S. President and DOE: Directives and Decisions	Federal Legislation, Judicial Decisions, and Regulatory Requirements Related to Nuclear Waste Disposal	Legal Challenges and New Mexico, National, and World Issues
1972 — Regional Characterization (SNL Phases)	**1972** Lyons site judged unacceptable 		★ **1972 - May:** AEC abandons Lyons project. AEC announces plans for Retrievable Surface Storage Facility (RSSF) for radioactive wastes. [D9] AEC Chairman asks for Probabilistic Risk Assessment (PRA) of core meltdown.	● **1972 -** EPA and anti-nuclear groups claim RSSF de facto permanent disposal in RSSF EIS. [F8, F9]	
1973	**1973** Carlsbad location chosen 	★ **1973 -** Nationwide search for suitable salt site resumed. [T21,T22,T23,T24,T25,T26,T27,T28,T29] AEC, USGS, and ORNL recommend southeastern NM (lack of boreholes 2 miles from site important selection criterion but relaxed to 1 mile in 1975).	● **1973 -** AEC Chairman: D.L. Ray		● **1973 -** With tacit approval of Gov. King, local political leaders and potash mine operators invite AEC to southeastern NM. (This strong local and political support from southeastern NM facilitates the WIPP process.) [N4] **Oct:** Arab oil embargo against U.S.
1974	**1974** Draft of 1st PRA on nuclear reactors  **1974** ORNL conducts scenario development and consequence analysis of WIPP 	★ **1974 - Mar:** ORNL begins field investigations for the Bedded Salt Pilot Plant (BSPP) by drilling AEC-7 and AEC-8. [T30, T31] **Aug:** Draft of first major Probabilistic Risk Assessment (PRA) published on two reactors by 60 member team for Nuclear Regulatory Commission (NRC); method uses fault trees to synthesize probability of total system failure. [T32] **Oct:** ORNL conducts first scenario development and deterministic analysis for WIPP. [T7] Probability of meteorite impact, probability of fault (and volcanism), and exploratory drilling intersecting disposal area estimated.	● **1974 -** AEC promises Idaho that wastes will be shipped in the 1980s. **May:** WIPP work suspended until 1975 because AEC wishes to emphasize RSSF and AEC Chairman Ray will not withdraw land from oil exploration because of oil embargo. [D10]	● **1974 - Oct:** Energy Reorganization Act [F10] splits AEC into Nuclear Regulatory Commission (NRC) and Energy Research and Development Agency (ERDA) effective January 1975.	● **1974 -** Gov. King establishes Governor's Technical Excellence Committee; creates WIPP oversight subcommittee.
1975	**1975** WIPP moved toward basin center 	★ **1975 - Mar:** Sandia National Laboratories (SNL) receives funding and starts four tasks: selecting site and characterizing, producing conceptual design, drafting EIS, initiating scientific studies. **May:** ERDA-6 drilled at NW corner of original ORNL site; encounters deformed salt beds and hits brine and H_2S much deeper. [T33] SNL recommends relocation and project moves site ~11 km (7 mi) toward center of Delaware Basin to avoid deformed salt beds as indicated by oil well logs. [T15, T34] SNL begins screening grouts to use for plugging boreholes. [T35]	● **1975 - Jan:** ERDA asks SNL, located in NM, to oversee investigations rather than ORNL and suggests an opening date of 1982. ERDA removes WIPP from commercial repository program.	● **1975 -** NRC promulgates "As Low As Reasonably Achievable" (ALARA) policy for limiting radiation exposure. [F11] **Oct:** NRC final PRA for nuclear reactors. [F12]	● **1975 -** AG: Anaya.
1976 — Siting Phase (DOE Phases)	**1976** ERDA-9 drilled at center of WIPP site  **1976** Ford orders demonstration of nuclear waste disposal  **1976** Bishop's Lodge Conference to explore PRA for geologic disposal 	★ **1976 -** SNL begins site characterization and engineering design program at new site; various natural backfills such as apatite or salt bentonite considered for use in repository. [T36] Parsons, Brinckerhoff, Quade, and Douglas, Inc. describe hypothetical HLW repository in bedded salt for Office of Nuclear Waste Isolation of ERDA. [T37] **Apr:** ERDA-9 drilled into Castile Formation near center of new site. Laboratory tests on TRU waste behavior and HLW packages initiated. [T38, T39]	★ **1976 - Jan:** Project is officially named the "Waste Isolation Pilot Plant." [D11] **Oct:** Ford orders major expansion of ERDA program to demonstrate permanent disposal for nuclear waste by 1985 and orders EPA to develop generally applicable standards. [D12, D13] ERDA funds conference on modeling of geologic disposal systems to bring engineers and geologists together to explore predicting geological features, events, and processes (FEPs). [D14]	● **1976 -** Resource Conservation and Recovery Act (RCRA) [F13] seeks to reduce or eliminate hazardous waste generation to minimize present and future threat to human health and environment. **Dec:** EPA announces intent to develop radiation protection standards for HLW disposal. [F10] NRC funds panel of earth scientists to identify events and processes that could disrupt a generic repository. [F14]	

Nixon Administration

Ford Administration

King Administration

Apodaca Administration

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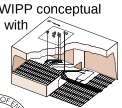
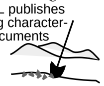
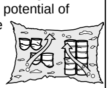
1977	**1977** WIPP conceptual design with two levels  **1977** DOE created	★ **1977 - Jun:** SNL issues conceptual design report of WIPP repository with two levels. [T40] WIPP conceptual design report issued. [T40] SNL plugs ERDA-10 to test plugging boreholes in salt. [T41, T42] INEEL begins risk analysis of alternatives for TRU waste stored and buried at RWMC over next 4 yr. [T43] Los Alamos, Savannah River, and Hanford begin similar studies as well. Human intrusion event significant contributor to consequences in these studies.	● **1977 -** DOE Sec: Schlesinger. **Apr:** Carter announces plan to defer indefinitely reprocessing of commercial spent nuclear fuel (SNF). [D15] **Nov:** Although role of NRC at WIPP unclear, DOE tells NRC it plans to seek license to build and operate WIPP based on policy from Carter administration. (WIPP returns to commercial waste repository program.)	★ **1977 - Oct:** DOE Organization Act [F15] creates cabinet-level Department of Energy (DOE) from ERDA. **Feb:** In response to Ford's directive, EPA conducts first public workshop to understand public concerns and technical issues of waste disposal. [F16, F17] **Apr:** Second meeting of NRC panel of earth scientists occurs to identify events and process. [F14]	● **1977 -** NM Hazardous Waste Act [N5] seeks to maintain environmental quality.
1978	**1978** Oversight by WIPP panel of NAS and NM EEG begins  **1978** SNL publishes supporting characterization documents for EIS  **1978** SNL adapts PRA for reactors to nuclear waste repositories  **1978** SNL tests gas generation potential of TRU waste 	★ **1978 -** SNL begins design of the Transuranic Package Transport, design I (TRUPACT-I) using standard cargo box concept. [T44, T45, T46] **Jan:** Bechtel National starts as WIPP Architect/Engineer (A/E). **Jun:** Westinghouse Electric Corp. starts as Technical Support Contractor. SNL raises concern about gas generation and contracts with Los Alamos to do laboratory tests. [T47] In response to DOE request to review scientific aspects of WIPP Project, WIPP Panel of BRWM of NAS holds first meeting. [T30] **Aug:** SNL completes geologic characterization report [T34] supporting Draft EIS on WIPP; transmissivity values of Culebra from four wells are available. [T48] Hydrologic and radioisotope transport modeling for EIS is primarily regional and extends for 250,000 yr (10 half lives of ^{239}Pu) using large, 3-D Swift flow model. [T49] NRC funds SNL to work on probabilistic PA and apply to hypothetical bedded salt repository. [T50, T51] **Nov:** Lab studies focus on titanium alloys for HLW canisters. [T42]	● **1978 -** DOE suggests opening date of 1985. [D16] DOE Deputy Sec. Jerry O'Leary promises NM Congressional delegation "if NM did not wish to have the WIPP, then it could veto the plan." Both Comptroller Gen. and DOE Gen. Counsel state O'Leary powerless to grant "state veto." [D17] DOE conducts local hearings on proposed WIPP. **Oct:** Deutch (Massachusetts Institute of Technology [MIT] chemistry professor) report written for DOE recommends (1) disposing TRU waste at WIPP without planning for retrieval and (2) demonstrating SNF, HLW, and TRU disposal at WIPP. [D18, D19] DOE Deputy Sec. J. O'Leary presses on with second recommendation until 1979 enabling law for WIPP as a way to satisfy California law banning nuclear power plants until SNF disposal demonstrated. [D10]	● **1978 - Jan:** EPA announces public forum to develop protection criteria for radioactive wastes. [F16] **Nov:** EPA publishes "Criteria for Radioactive Wastes" as guidance for federal agencies and seeks comments. [F18]	★ **1978 -** DOE contracts with NM to establish Environmental Evaluation Group (EEG) to provide a full-time, independent assessment of WIPP and oversee environment, public health and safety. Although DOE-funded, EEG is initially made a part of Environmental Improvement Division of the NM Health & Environment Department. The general understanding is neither DOE nor NM would attempt to bias or interfere in EEG's technical conclusions. EEG becomes second permanent outside oversight group set up by DOE (first was NAS WIPP Panel of BRWM). NM House almost passes ballot proposal for constitutional amendment to keep nuclear waste from NM.
1979	**1979** Congress defines mission of WIPP and passes WIPP bill for TRU waste only  **1979** Draft EIS on WIPP has option for commercial SNF and conducts transport analysis of Pu out to 250,000 yr 	★ **1979 -** To develop necessary predictive capability, [T52] SNL begins 3-yr preliminary test programs on thermal/structural effects in nearby potash mine, [T53] and Avery Island, Louisiana, dome salt. [T54, T55] Consolidation of crushed salt studied. [T42] First in situ permeability measurement of Salado Formation salt from AEC-7 well (values 1000 times larger than found when measured within repository in 1988) [T56]; Bechtel identifies seven potential horizons for WIPP. SNL completes development of scenarios for release from WIPP (part of EIS process). [T57] Laboratory measurements made of permeability on ERDA-9 core. [T42] **Apr:** Draft EIS on WIPP published. [T49] As part of EIS process, SNL completes development of scenarios for release of radioisotopes from WIPP (method abandons fault trees and uses simple event trees). [T57, T58] Three major classes of scenarios identified (connection between Culebra [above repository] and Bell Canyon [below repository] aquifers, U-tube connection to Culebra, and stagnant pool connection to Culebra) plus drilling intrusion. (Later U-tube split into catastrophic connection and standard U-tube connection.) [T49] Probabilities of scenarios assigned based on qualitative reasoned arguments. **Jul:** Preliminary Title I design of WIPP completed.	★ **1979 - Mar:** President forms Interagency Review Group (IRG), in response to Deutch report to recommend type of nuclear waste disposal, and recommends disposal of SNF, HLW, and TRU in mined geologic repositories in final report. [D20] Report also suggests making WIPP candidate for commercial SNF repository. **Apr:** DOE defines project as a combination military/commercial repository in Draft EIS. [D16, D21] Based on salt permeability tests in AEC-7 well, DOE cancels all gas generation and some backfill experiments. DOE buys oil and gas leases for $19 million.	★ **1979 - May:** House Armed Services Committee cuts WIPP funding in response to O'Leary's (DOE's) expansion of the project to a repository for commercial SNF and thus requiring NRC licensing (even if for demonstration only). **Dec:** Congress defines mission [F19] of WIPP: - sets up WIPP as a research and development facility for disposal of only TRU radioactive waste from DOE facilities - exempts WIPP from NRC licensing - requires DOE to sign a "Consultation & Cooperation" (C&C) Agreement with NM. EPA defines TRU waste as waste with activity greater than 100 nCi/g. [F20]	● **1979 -** AG: Bingaman. Legislature establishes (1) Governor's Radioactive Waste Consultation Task Force to negotiate with DOE and (2) Legislative Radioactive and Hazardous Materials Committee to review task force. [N6]

Regional Characterization (SNL Phases)

Siting Phase (DOE Phases)

Carter Administration

Apodaca Administration

King Administration

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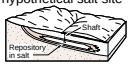
Milestones for Disposal of Radioactive Waste in the United States

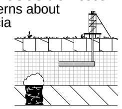
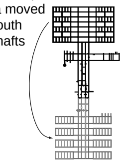
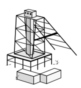
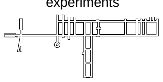
Time Line	Noteworthy Events	Technical Milestones Related to the WIPP	U.S. President and DOE: Directives and Decisions	Federal Legislation, Judicial Decisions, and Regulatory Requirements Related to Nuclear Waste Disposal	Legal Challenges and New Mexico, National, and World Issues
1980	**1980** Final EIS on WIPP 	● **1980 -** Westinghouse completes first Safety Analysis Report (SAR). [T59] General Atomic Technologies started as A/E for TRUPACT-I (used SNL basic concept but changed details). SNL asked to analyze and test TRUPACT-I when built.	★ **1980 - Feb:** Carter orders SNF reprocessing to stop. [D22] **Mar:** Carter rescinds 1980 funds for WIPP and announces interim strategy to set aside money for possible future waste disposal projects at WIPP. **Oct:** DOE issues final EIS eliminating SNF and HLW disposal and thereby reinstates WIPP mission defined by Congress in 1979. [D1] **Nov:** DOE applies to Department of Interior (DOI) for administrative withdrawal of land for Site and Preliminary Design Validation (SPDV) experiments at WIPP. [D23]	● **1980 - Jul:** House Armed Services Committee disagrees with Carter proposal; therefore, rescinded funds are returned to WIPP mid-year.	● **1980 -** NM and DOE begin negotiations on C&C Agreement to define procedures and process of cooperation.
1981	**1981** First shaft drilled  **1981** SNL reports on PA of hypothetical salt site  **1981** Stipulated agreement between DOE and New Mexico signed 	★ **1981 -** Tests begun in nearby potash mine, Mississippi Chemical Mine Co., to evaluate corrosion of potential waste canisters and overpack alloys. [T60] **May:** WIPP begins augering for first shaft, which ushers in SPDV phase of WIPP. Fenix & Scisson, SPDV construction contractor, begins augering first shaft (this exploratory shaft later called construction and salt handling shaft and then salt handling shaft). [T61, T62] **Jun:** Drilling of second 3.6 m shaft begins (this waste shaft initially called ventilation shaft). **Jul:** Drilling on first shaft begins. Stipulated Agreement (SA) between New Mexico and DOE describes disruptive scenarios (e.g., breccia pipe, salt dissolution, and salt deformation) that are to be dismissed through further site characterization. [T63] **Oct:** First 3.6 m shaft completed. **Nov:** Project strikes pressured brine reservoir [T64] while deepening WIPP-12 north of the repository (as part of Stipulated Agreement [SA]). Extensive tests and analysis continue on WIPP-12 through 1983. [T48] Three tests set up in nearby Mississippi chemical potash mine to evaluate fluid migration in salt formations. [T60] **Dec:** Drilling of second shaft begins. Draft of final report to NRC on performance assessment (PA) of hypothetical bedded salt repository readily available [T51, T65] – uses a set of loosely connected codes, precursors to SWIFT II [T65] (fluid flow code), and NEFTRAN [T66] (network transport code). IAEA recommends procedure for PA and potential list of events and processes for scenarios. [T67]	● **1981 - Jan:** DOE publishes Record of Decision to proceed with SPDV phase. [D24] **Feb:** After reviewing preliminary design, DOE okays detailed (Title II [D25]) design phase. DOE Sec: Edwards. **Jun:** DOE WIPP Project Mgr. McGough rekindles disagreements between DOE and New Mexico by stating HLW could be placed by 1983 and remain during the operating phase of WIPP. **Sep:** After reviewing preliminary design, DOE okays detailed design phase. [D25]	● **1981 - Feb:** NRC promulgates licensing procedures for SNF and HLW disposal in geologic repositories. [F21] District Court denies Citizens for Alternatives to Radioactive Dumping (CARD) motion for a preliminary injunction against constructing WIPP. Draft (but not final) Nuclear Waste Policy Act (NWPA) defines TRU waste as waste contaminated with transuranic radioisotopes with half-life greater than 20 yr and activity greater than 100 nCi/g. [F22] **Mar:** Developing generic disposal criteria for radioactive wastes is difficult, thus EPA starts developing standards for each waste type. [F23]	★ **1981 - Jan:** In response to Record of Decision DOE proceeds with SPDV: • **Mar:** CARD files lawsuit and asks for preliminary injunction. [N7] • **May:** NM AG sues DOE and DOI alleging violations of federal and state laws. [N8] • **Jul:** Southwest Research and Information Center (SWRIC) files lawsuit [N9] and begins strategy of filing numerous interrogatories to which DOE must respond. In response to lawsuits, [N8] DOE Sec. Edwards visits NM, talks to Gov. King, and accedes in a Stipulated Agreement (SA) to demands for (1) geotechnical experiments, (2) SNL report on 17 technical issues (e.g., disruptive scenarios such as breccia pipe, salt dissolution, and salt deformation that are to be examined by SNL), (3) state and public review of WIPP changes, and (4) creation of a state/federal task force to oversee transportation issues (e.g., emergency response and highway upgrades). C&C Agreement attached as Appendix A, "Working Agreement" as Appendix B. [N8] U.S. Dist. Judge Burciaga stays lawsuit in accordance with SA. Coalition for Direct Action at WIPP demonstrates against construction. EEG recommends relocating TRU storage away from WIPP-12.

Siting Phase (DOE Phases) — Disposal System Characterization - SPDV

Carter Administration

Reagan Administration

King Administration

1982	SPDV	**1982** USGS dismisses concerns about breccia pipes  **1982** Disposal area moved to south of shafts 	★ **1982 - Mar:** Second 1.8 m shaft completed (~80 m [270 ft] of drilling fluid left in the shaft). Westinghouse suggests eliminating fourth shaft along with other cost saving measures.[T61, T62] **May:** Repository level selected. **Jun:** Army Corps of Engineers assumes responsibility for all phases of construction management. **Jul:** Drilling of DOE-1 started and completed to top of Anhydrite I in Castile Fm. **Oct:** Underground excavation started to connect the two shafts. **Nov:** Excavations connect the two existing shafts. Following evaluation of WIPP-12, TRU disposal area moved ~1800 m (6000 ft) south (experimental area left in original area). Schedule calls for opening WIPP in April 1989. First shaft sealing concepts presented. SNL publishes report outlining in situ tests to perform in next several years.[T68] **Dec:** SNL completes interim report on dissolution of evaporites in and around the Delaware Basin [T69] (part of SA). USGS completes breccia pipe report (part of SA) and dismisses concerns.[T70]		● **1982 -** Courts decline to relieve DOE from responding to numerous SWRIC interrogatories. **Mar:** DOI approves DOE's application for administrative withdrawal of 36 x 10^6 m^2 (8960 acres) for conducting SPDV experiments for 8 yr.[F24] **Dec:** NWPA passes[F25]: - sets up trust fund, funded by utilities, to pay for SNF and HLW repository - requires NRC licensing of repository - sets acceptable risk of 1000 deaths/ 10,000 yr - states SNF and HLW from DOE facilities will go to repository unless President objects - suggests DOE build Monitored Retrievable Storage (MRS) Facility EPA publishes working draft 20 of environmental standards for radioactive waste management as proposed 40 CFR 191.[F26]	● **1982 - Dec:** Supplemental SA signed (1) committing DOE to seek funds for upgrading highways in NM, (2) committing DOE to more geotechnical studies, and (3) making DOE liable for WIPP-related accidents.[N10] King Administration
1983	Disposal System Characterization	**1983** Full construction begins 	★ **1983 - Mar:** SNL, USGS, and contractors complete most reports required by SA (e.g., USGS reports Culebra transmissivity at 20 locations[T48, T71]; SNL reports on groundwater flow in Rustler Fm.[T72] and deformation of evaporites near WIPP[T73]; technical support contractor, Westinghouse, reports on brine reservoirs in the Castile Fm.[T64]). Excavation of experimental rooms begins, and Bechtel begins final (Title III) design. **Apr:** WIPP Panel NAS tours WIPP underground to examine SPDV tests.[T74] **May:** Repository level selected. **Oct:** Drilling of pilot hole for third shaft begins (exhaust shaft) and is completed in December.[T61, T62] **Aug:** Deepening of Cabin Baby started and completed to Bell Canyon Fm.; geophysical logs run and deep sandstones in Bell Canyon hydrologically tested.[T75, T76]	● **1983 -** DOE Sec: Hodel. **Mar:** DOE gives SPDV reports to NM and allows 60-day comment period.[D26] In response to questions by EEG, DOE concludes draft 40 CFR 191 applies to disposal phase but not test phase of WIPP. **May:** ORNL complex admits releasing 2 x 10^6 lb of Hg from Y-12 plant between 1950 and 1977. Revelation prompts Natural Resources Defense Council (NRDC) and Legal Environmental Assistance Foundation (LEAF) to sue DOE.[D27] **Jul:** DOE announces decision to proceed with construction.[D28] **Sep:** DOE sets October 1988 as WIPP opening date. Reagan Administration	● **1983 -** Congress allocates $5.8 M for road improvement in NM. **Jan - Sep:** EPA's Science Advisory Board (SAB) holds public meetings on 40 CFR 191. **Jun:** DOI approves land withdrawal for 8 yr for a 36 x 10^6 m^2 area to construct WIPP.[F27] NRC promulgates technical criteria for waste disposal in geologic repositories and includes by reference the yet-to-be promulgated EPA standard on waste disposal.[F28]	● **1983 -** AG: Bardacke. **May:** After reviewing results from SPDV program, EEG concludes that "...the Los Medaños site has been characterized in sufficient detail to warrant confidence in the validation of the site for permanent emplacement of approximately 6 million ft^3 (1.75 x 10^5 m^3) of defense TRU waste," but also recommends additional studies to resolve outstanding geotechnical issues such as evaluation of potential for brine reservoirs.[N11] **Aug:** EEG issues report and Governor holds press conference on concern about potentially explosive hydrogen gas in TRUPACT-I.[N12] **Sep:** CARD and Sierra Club allege that DOE and EEG are collaborating to deceive NM about safety of WIPP; they also insist on NRC licensing of WIPP. Anaya Administration
1984	Full Construction Phase	**1984** SNL begins fielding many underground experiments 	★ **1984 - Feb:** Raised bore reaming completed of third shaft. **Apr:** As rooms excavated, SNL begins many thermal/structural and waste package (e.g., defense HLW) field tests defined in 1982, ushering in the system characterization phase of project.[T42, T68, T77] Pumping tests at DOE-1 suggest fracture flow in Culebra. First in situ gas flow measurement conducted around underground drift.[T78] **Jun:** Second shaft enlarged from 1.8 m to 6 m.[T61, T62] **Aug:** SNL drills and tests DOE-2.[T79] General Atomic Technologies completes one container; SNL sends it to ORNL test facility because container exceeds SNL weight limit for 30 ft drop and puncture test, etc., required in 10 CFR 71[T80]; container passes tests.	● **1984 - Mar:** Manager of Albuquerque Operations Office (AL) moves WIPP Project Office (WPO) to Carlsbad.	● **1984 - Feb:** EPA SAB endorses probabilistic approach of 40 CFR 191 but states performance criteria too restrictive and recommends several changes.[F29] **Apr:** LEAF vs. Hodel[F30] requires DOE to apply both the technical and procedural requirements of RCRA to DOE facilities even though AEA exempted DOE from many environment and human health laws. **Nov:** Hazardous and Solid Waste Amendments (HSWA)[F31] to RCRA ban land disposal of hazardous waste without treatment unless disposal site and generator demonstrate "no migration" of constituents for as long as waste remains hazardous.	● **1984 - Nov:** First modification to C&C Agreement limiting remote-handled (RH) TRU waste amount to 5.1 x 10^6 Ci.

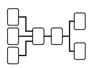
Milestones for Disposal of Radioactive Waste in the United States

Time Line	Noteworthy Events	Technical Milestones Related to the WIPP	U.S. President and DOE: Directives and Decisions	Federal Legislation, Judicial Decisions, and Regulatory Requirements Related to Nuclear Waste Disposal	Legal Challenges and New Mexico, National, and World Issues
1985	**1985** EPA promulgates 40 CFR 191 **1985** SNL reports on discrepancy in creep first hinted at in 1982	★ **1985 - Jan:** Blasting of third shaft to final 4.6 m diameter completed. Excavation begins for circular room H. SNL reports on discrepancy between measured and predicted salt creep first hinted at in south drift in 1982. [T81, T82] General Atomic Technologies disassembles TRUPACT-I and cuts in half; half with door rebuilt; while rebuilding, puncture damage replicated to match damage in original TRUPACT-I. With the definition of a 5-km boundary to the disposal system in 40 CFR 191, project begins to focus more on near-field hydrologic modeling rather than regional modeling. **Apr & Oct:** SNL turns on heat for simulated defense high-level waste (DHLW) canister experiments.	● **1985 -** DOE Sec: Harrington. President approves the three repository candidates as recommended by DOE for SNF and HLW. President concurs with DOE recommendation that defense SNF and HLW be disposed of in commercial repository. **Nov:** DOE attempts to define "by-product material" to include mixed waste and thus exclude EPA regulation.	★ **1985 -** Office of Technology Assessment (OTA), an agency of Congress, concludes no insurmountable technical obstacles for geologic repositories. [F32] **Sep:** EPA promulgates 40 CFR 191 for disposal of SNF, HLW, and TRU in a geologic repository [F17]: - probabilistic criteria indirectly based on population health risk - requests inclusion of all uncertainty In 40 CFR 191, EPA defines TRU waste as waste with activity greater than 100 nCi/g and half-life greater than 20 yr. Promulgation begins the transition of the WIPP to compliance phase.	● **1985 - Jan:** NM receives EPA authorization to regulate hazardous wastes. [N13] **Feb:** Natural Resources Defense Council (NRDC) sues EPA to issue 40 CFR 191 as mandated in NWPA of 1982. [N14] EEG notifies DOE that the single-shelled, vented rectangular transportation container for TRU waste, TRUPACT-1, is unacceptable for NM. [N15]
1986	**1986** EPA states mixed waste subject to RCRA (potentially ~60% of WIPP waste)	● **1986 - Feb:** Pillar creep test begins in circular room H. Heated (accelerated) tests of CH-TRU and RH-TRU container behavior start. TRUPACT-I passes firetest at SNL. [T83, T84] First in situ injected brine flow measurement to determine permeability around drifts. [T42] **Oct:** In preparation for operations, Westinghouse awarded Management & Operation (M&O) contract. Army Corps of Engineers relieved of construction management duties.	● **1986 - Aug:** DOE asks SNL to assess performance of WIPP against 40 CFR 191 criteria (Performance Assessment [PA]). [D29] SNL accepts PA task. [D30]	★ **1986 -** EPA states that mixed waste (radioactive waste also meeting hazardous waste definition) is subject to RCRA and hazardous waste regulations. [F33] NRC promulgates probabilistic safety goals for nuclear reactors that are similar to 40 CFR 191. [F34]	● **1986 - Mar:** NRDC and others sue EPA over groundwater and individual protection standards in 40 CFR 191.
1987	**1987** Brine pockets cannot be dismissed	★ **1987 -** SNL finds possibility of a pressurized brine reservoir below the TRU disposal area cannot be ruled out. [T74, T76] Lack of double containment in TRUPACT-I becomes major issue. [T85, T86] Wet salt compaction tests concluded, constitutive equation for consolidation developed, and shaft consolidation modeled (effective consolidation predicted in < 100 yr). [T42] **Mar:** SNL finds that porous-media flow assumption adequately models flow in Culebra at H-3 but that transport is best modeled as dual porosity media [T87] (though roughly approximated as equivalent porous media). [T76, T88, T89] Modeling with variable brine densities suggests Culebra acting as leaky confined aquifer; [T87] subsequent models ignored suggestion until 1997. Also model suggests highly transmissive zone in the Culebra to the south of H-11 and DOE-1. [T87] **Oct:** Nuclear Packaging becomes A/E for the Transuranic Package Transport, design II (TRUPACT-II); SNL again selected as DOE technical advisor.	● **1987 - May:** DOE redefines "by-product material" to exclude everything except radionuclides, and thereby TRU waste is subject to RCRA (and HSWA). [D31] **Jul:** Agreement between Department of Labor (DOL) and DOE on mine inspections. [D32] **Oct:** DOE selects Nuclear Packaging conceptual design for TRUPACT-II.	● **1987 - Jul:** In response to legal challenges to individual and groundwater protection requirements in subpart B, Court of Appeals for first Circuit in Boston vacates and remands all of 40 CFR 191 to EPA. [F34] **Sep:** Court reinstates Subpart A of 40 CFR 191 in response to EPA request. **Dec:** Nuclear Waste Policy Amendments Act (NWPAA) [F35] selects Yucca Mt., NV, to undergo site characterization for potential SNF and HLW disposal; because bedded salt not being considered, SNF and HLW tests at WIPP unnecessary.	● **1987 -** AG: Stratton. Anticipating conflicts between radioactive and hazardous waste regulations, NM legislature exempts WIPP from hazardous waste regulations. **Aug:** second modification to C&C Agreement committing DOE to comply with all applicable laws and regulations, and discourage WIPP compliance by way of grandfathering, variance, exemption, or waiver; and use 40 CFR 191 as first issued for evaluating WIPP compliance until reissued by EPA; NRC and Department of Transportation (DOT) regs apply to WIPP transport. **Dec:** Environmental groups raise concern of brine seepage into repository. [N16]

Disposal System Characterization — Full Construction Phase — Compliance Evaluation

Anaya Administration | Reagan Administration | Carruthers Administration

TRI-6342-6218-0

Year	Events				
1988	**1988** Brine seepage into WIPP big issue 	★ **1988 - May:** WIPP begins drilling fourth shaft (air intake shaft) after reevaluating 1982 decision to eliminate it. **Sep:** SNL reports on in situ permeability (1000 times lower than 1979) and small potential brine inflow.[T90] Members of NAS BRWM (not WIPP Panel) study brine inflow; conclude no problem but suggest brine inflow test and less waste be used for pilot phase. First prototype of TRUPACT-II passes structural tests, but fails engulfing fire test at seals. SNL begins work on CAMCON to link detailed consequence models in probabilistic PA.[T31, T91, T92] SNL also simultaneously begins work on prototype of CAMCON to meet Dec. 1989 deadline. SNL completes pumping tests at H-11[T93] and begins using results to calibrate regional flow model.[T94, T95]	● **1988 - Sep:** DOE announces that WIPP will not open as scheduled in Oct. **Dec:** DOE abruptly cancels SNF and HLW experiments because of NWPAA (no funds available to remove and examine simulated disposal containers).	● **1988 -** NM Congressmen ask NAS BRWM to study brine inflow controversy. With continued technical problems (e.g., TRUPACT-II not yet licensed), NM Congressional delegation cannot reach consensus, and WIPP Land Withdrawal legislation dies. NM Congressmen get Congress to reassign EEG to the New Mexico Institute of Mining and Technology in Socorro in Sep because of conflicts between NM state government and EEG.[F36] Congressman Richardson insists upon full compliance of WIPP with 40 CFR 191 before receipt of any waste and funding for roads attached to bill.[F37]	● **1988 - Jan:** EEG issues report on potential brine reservoirs under WIPP. **Oct:** Idaho Gov. Andrus bans shipments of radioactive waste into state because WIPP not open. **Dec:** ID Gov. Andrus, CO Gov. Romer, and NM Gov. Carruthers meet in Salt Lake City to discuss WIPP and options to avert shutdown of DOE Rocky Flats Plant from lack of storage authorized by CO, and inability to ship to ID because of imposed ban by Gov. Andrus; DOE agrees to vigorously pursue both administrative and legislative land withdrawal for WIPP.[N17]
1989	**1989** Draft Supplemental EIS identifies gas generation as issue  **1989** Berlin Wall falls  **1989** Demo for WIPP PA 	★ **1989 -** SNL reports on reevaluation of Culebra permeability at AEC-7 and D-268 wells[T96]; Culebra transmissivity available at 41 locations.[T48] **Jan & Feb:** Redesigned seals of TRUPACT-II pass engulfing fire test.[T97] **Jan - Aug:** Q tunnel mined and instrumented for brine inflow experiment.[T98] **Feb:** SNL resolves discrepancies between measured and predicted salt creep.[T99] Westinghouse completes "no-migration" petition for RCRA variance for WIPP pilot phase.[T100, T101] **Mar:** SNL completes report to support Draft Supplemental EIS; report identifies generation of gases from container and waste corrosion as issue (see 1978) because salt permeability factor of 1000 lower than thought in 1979. Based on initial analysis results in February, DOE funds SNL to conduct new studies of gas generation.[T102, T103, T104, T105, T106, T107] Also, different flow direction in past during wet climate hypothesized to explain discrepancy between geochemical analysis and current hydrologic flow in Culebra.[T48] DOE issues Draft Supplemental EIS.[T108, T109] **Dec:** SNL reevaluates release scenarios and issues WIPP PA demonstration outlining process for future PAs.[T110, T111] No release without human intrusion; out of 26 parameters, solubility, intrusion time, and borehole permeability most important; cuttings from direct drilling set at three drums.	● **1989 -** DOE Sec: Watkins. **Jan:** DOE files request for administrative withdrawal of 16 mi^2 with DOI (less than half of land allowed by 40 CFR 191).[D33] **Mar:** DOE issues Draft Supplemental EIS.[D34] Watkins creates "Blue Ribbon Panel" to examine WIPP readiness. **Jun:** Watkins announces an indefinite delay in opening of WIPP. Watkins creates "tiger teams" to examine environment, safety, and health issues throughout DOE defense complex.[D35]	● **1989 - Aug:** NRC approves the pressurized transportation container for shipping contact-handled (CH) TRU to TRUPACT-II.	★ **1989 -** Legislature unanimously removes "WIPP exemption" in hazardous waste laws so EPA will grant authority to regulate radioactive mixed waste. **Nov:** Berlin Wall falls signaling the end of the Cold War and greatly changing future demands for nuclear weapon material and, thus, amount and composition of TRU waste going to WIPP.

Full Construction Phase

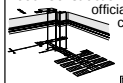
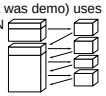
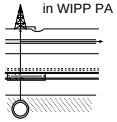
Compliance Evaluation

Bush Administration

Carruthers Administration

TRI-6342-6219-0

Milestones for Disposal of Radioactive Waste in the United States

Time Line	Noteworthy Events	Technical Milestones Related to the WIPP	U.S. President and DOE: Directives and Decisions	Federal Legislation, Judicial Decisions, and Regulatory Requirements Related to Nuclear Waste Disposal	Legal Challenges and New Mexico, National, and World Issues
1990	**1990** Construction officially complete  **1990** Supplemental EIS  **1990** First full PA of WIPP (1989 PA was demo) uses CAMCON 	★ **1990 - Jan:** Construction officially complete. SNL and Westinghouse complete report on the pilot test phase of WIPP [T112] suggesting that a waste amount equal to 0.5% of capacity be brought to WIPP for gas generation experiments. **May:** Westinghouse completes "Final" Safety Analysis Report. [T113] SNL refines FEP screening and analyzes four scenarios (E0, E1, E2, E1E2). [T114] **Dec:** SNL issues first full PA highlighting use of CAMCON modeling system [T115, T116, T117] (e.g. secondary parameter database completed). Coupling of code demonstrated, which allowed better evaluation such as sensitivity analysis. PA includes both scenario and parameter uncertainty: out of three parameters, solubility, intrusion time, and borehole permeability important; cuttings from direct drilling important release pathway.	★ **1990 - Jan:** DOE issues Final Supplemental EIS. [D36] **Jun:** DOE issues "Record of Decision" on WIPP Final Supplemental EIS stating construction is officially complete, testing phase (~5 yr) should proceed, and then another Supplemental EIS should be prepared before going to full operation. [D37]	● **1990 - Oct:** EPA issues no-migration variance for test phase of WIPP. [F38]	● **1990 - Jul:** NM granted authority by EPA to regulate radioactive mixed waste, and thus WIPP waste becomes subject to NM regulations. [N18] NM Environmental Improvement Division requests submittal of Parts A and B of RCRA permit. **Oct:** NM designates "preferred route" for waste transport from northern border to WIPP.
1991	**1991** Major models linked in WIPP PA 	★ **1991 -** Westinghouse completes Parts A and B of RCRA permit application. [T118] **Apr & Aug:** To extend life of room 1, panel 1 for gas generation tests, internal and external panels meet and recommend roof support. **Sep:** Westinghouse completes construction of roof support. [T119, T120] **Dec:** SNL issues second PA highlighting major components of the PA process and documents [T121] (e.g., rigorous use of scenarios and geostatistics for transmissivity fields); 46 parameters sampled; cuttings most important release pathway.	● **1991 -** In response to audit, AL manager creates WIPP Project Integration Office (WPIO) in Albuquerque over WPO in Carlsbad.	● **1991 - Jan:** DOI modifies administrative land withdrawal order to allow test phase of WIPP. [F39, F40, F41] **Mar:** House Interior Committee adopts NM Congressman Richardson's resolution to nullify DOI-modified land withdrawal order (action allowed under Federal Land Policy and Management Act [FLPMA]). [F42] **Sep:** 9th Circuit Court of Appeals rules state ban on radioactive waste shipments imposed by Gov. Andrus of Idaho is illegal. [F43] **Oct:** DOI again grants administrative land withdrawal after Watkins certifies all environmental permitting requirements have been met. [F44]	● **1991 -** AG: Udall. **Oct:** AG Udall files 1000-page lawsuit in U.S. District Court for the District of Columbia to delay start of test phase at WIPP by challenging the administrative land withdrawal. [N19]

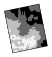
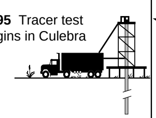
Test and Predisposal Phase ↑ Compliance Evaluation

Bush Administration

Carruthers Administration

King Administration

TRI-6342-6220-0

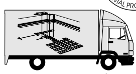
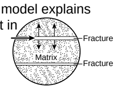
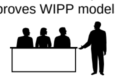
Year	Phase	Events	SNL / Technical	DOE	Federal	State / Local
1992	Compliance Evaluation	 **1992** Refinements to models (e.g., transmissivity fields) in WIPP PA **1992** Congress passes Land Withdrawal Act  **1992** NAS questions need for in situ gas generation tests 	★ **1992 -** SNL and Westinghouse complete work necessary to modify Test Phase Plan for gas generation tests. T122 Westinghouse completes work necessary for modifying Waste Retrieval Plan. T123 **Jun:** NAS WIPP Panel sends letter to DOE questioning scientific need for in situ waste tests at WIPP. T124 **Dec:** SNL issues third PA refining models and data used in the PA, uncertainty in transmissivity fields refined, 49 parameters sampled, evaluated time-dependent λ parameter in Poisson intrusion model; direct cuttings most important pathway. T125	● **1992 - Aug:** DOE submits application to New Mexico Environment Department (NMED) for RCRA permit for test phase.	★ **1992 - Oct:** WIPP Land Withdrawal Act (LWA) F45: - transfers land from DOI to DOE - establishes EPA as regulator for WIPP (removing self-regulation by DOE); compliance requirements (different from WIPP Panel or EEG) to be set in 40 CFR 194 - requires recertifying site every 5 yr - reinstates Subpart B of 40 CFR 191, except disputed aspects of individual and groundwater protection requirements - requires DOE cooperation and consultation with EEG - NM given $600 million over 30 yr Energy Policy Act F46: - asks NAS to recommend disposal criteria for Yucca Mt. - requires EPA and NRC to reevaluate their disposal criteria for Yucca Mt. Federal Facility Compliance Act F47: - waives federal sovereign immunity for civil and criminal liability for RCRA violations and thus brings DOE facilities under jurisdiction of states but exempts mixed waste stored by DOE Washington DC District Court Judge Penn grants preliminary injunction to stop testing with TRU waste at WIPP. Penn rules WIPP does not qualify for interim status under RCRA, thus must get permits before rather than during operation.	● **1992 -** Environmental Defense Fund (EDF) and NRDC join the NM lawsuit and seek to make RCRA issues more important (e.g., interim status of WIPP). N20
1993	Test and Predisposal Phase	**1993** DOE decides not to test waste at WIPP **1993** EPA repromulgates 40 CFR 191	● **1993 -** Brine inflow to Q tunnel can be explained as either dewatering of disturbed rock zone or Darcy flow through salt.	★ **1993 -** DOE Sec: Hazel O'Leary. **Oct:** DOE concurs with NAS and decides not to emplace waste in a pilot phase at WIPP – lab tests instead. D38 DOE decides to make draft Compliance Certification Application (CCA) to EPA. Because actual waste not coming to WIPP, "bin tests" cancelled. **Dec:** O'Leary disbands WPIO in Albuquerque and selects new personnel for Carlsbad Area Office (CAO) (old WPO with new functions) and direct reporting to Undersecretary T. Grumbly. D39	★ **1993 - Feb:** EPA announces intent to promulgate 40 CFR 194 to specify requirements for implementing 40 CFR 191 at WIPP. F48 **Dec:** In response to court remand and WIPP LWA, EPA repromulgates 40 CFR 191 to address individual and groundwater protection requirements, and makes other changes – no influential changes for WIPP. F49	● **1993** - Mayor Forrest of Carlsbad demands more economic benefits accrue to city of Carlsbad from WIPP. N21, N22 NMED issues Draft RCRA permit for test phase. N23
1994			● **1994 - Mar:** SNL explores possibility of linking PA with decision analysis in System Prioritization Methodology (SPM); results form basis of Draft Compliance Certification Application (DCCA). **Aug**: SNL seeks permits to drill new wells for tracer test in Culebra.		● **1994 -** Congress authorizes funding for EEG for additional 5 yr. F50	
1995		**1995** Tracer test begins in Culebra 	★ **1995 - Feb:** Drilling of wells for tracer tests begins. **Sep:** Gas generation studies completed and results used to establish rates for CCA. T126, T127 **Oct:** IT Corp. completes cost/benefit study for Westinghouse and DOE of engineered barrier alternatives required by 40 CFR 194. T128 **Dec:** DOE publishes updated revision of WIPP inventory. T129 Computer specialists hired to modify CAMCON implementation to enforce software configuration management and control runs for PA calculations. Second attempt at SPM.	● **1995 - Mar:** DOE submits DCCA to EPA for review. D40 **May:** DOE submits Part B of RCRA permit application to NMED. D41 **Oct:** DOE halts all in situ experiments and closes area in repository.	● **1995 -** NAS provides guidance on new regulation for potential Yucca Mt. repository; suggests reporting risk from human intrusion separately. **Jan:** EPA proposes compliance criteria for WIPP in 40 CFR 194. F51 **May:** DOE comments that 40 CFR 194 exceeds scope of 40 CFR 191. **Oct:** EPA issues draft of non-binding Compliance Application Guide (CAG). F52	

Clinton Administration

King Administration

Johnson Administration

Milestones for Disposal of Radioactive Waste in the United States

Time Line	Noteworthy Events	Technical Milestones Related to the WIPP	U.S. President and DOE: Directives and Decisions	Federal Legislation, Judicial Decisions, and Regulatory Requirements Related to Nuclear Waste Disposal	Legal Challenges and New Mexico, National, and World Issues
1996	**1996** EPA states how to implement radioactive waste standard in 40 CFR 194  **1996** SNL completes PA for WIPP certification; moving van required to send copies to EPA **1996** Tests on solubility reported  **1996** SNL concludes dual porosity model explains transport in Culebra  	★ **1996 - Apr:** SNL completes tracer test in Culebra; decides dual-porosity model reasonable and single-porosity transport alternative model could be ruled out. [T131, T132] **Jul:** SNL reports on early results of retardation batch experiments. [T133, T134] Tests on solubility reported for use by CCA. **Oct:** SNL completes PA for CCA of WIPP that includes MgO backfill mining scenario, and greater intrusion rate; except for few vectors, drill cuttings only release pathway; 57 parameters sampled. [T135, T136] Calculation run three times with 100 samples each, takes 37,000 CPU hrs on 40 DEC alpha processors, and retains 100 GB of data in 97,000 files. **Nov:** NAS reports that WIPP site "excellent choice" geologically. [T137, T138]	★ **1996 - Oct:** DOE sends 80,000-page, 400-lb. CCA to EPA. [D42] **Nov:** DOE issues 84,000-page second Supplemental Draft EIS. [D43, D44]	★ **1996 - Feb:** EPA promulgates final 40 CFR 194; directs DOE to consider additional criteria in assessing system performance [F53]: - requires waste characterization analysis and engineered barrier evaluation - requires a monitoring system - specifies requirements on quality assurance (QA), peer review, and expert judgment - requires peer review on waste characterization, engineered and natural barriers, and conceptual models - expands human activities (e.g., potash mining) to consider in performance assessment **Sep:** Congress amends WIPP LWA and relieves WIPP of need to comply with land disposal restrictions of RCRA, but other requirements of RCRA still apply. [F54] **Dec:** EPA begins detailed evaluation of CCA and supporting information at SNL and elsewhere, including SNL PA conceptual models, computer codes, model parameters, QA records, and specific technical issues (e.g., MgO backfill and passive institutional control). [F55]	● **1996 - Apr:** NM AG Udall sues EPA alleging improper meetings were held between EPA and DOE about requirements in proposed 40 CFR 194 regulation. [N24]
1997	**1997** Conceptual Model Peer Review Group approves WIPP models 	★ **1997 - Jan:** Conceptual Model Peer Review Group (formed in response to 40 CFR 194) concludes 22 of 24 conceptual models adequate. Spallings model must be redone because unrealistic and MgO backfill description improved. **Mar:** SNL conducts mini-PA for EPA to do parametric sensitivity analysis of PA model parameters lacking "iron-clad" defense. **Apr:** Conceptual Model Peer Review Group reports that with additional information provided by SNL, they are satisfied that the model of the MgO backfill is adequate [T139] and that they have sufficient understanding of how much the spallings model overestimates spall volumes. [T140] DOE commits to develop a less conservative, more realistic spallings model by the time of recertification. **May:** SNL explains apparent discrepancy between geohydrology and geochemistry by viewing flow in Culebra as a 3D regional system. [T141] As part of EPA evaluation of CCA, SNL runs PA calculations using EPA-selected values for 26 parameters and EPA-selected model assumptions, based on results from parameter review team comments in Dec 96 and sensitivity analysis in Mar 97.	● **1997 -** DOE Secretary: Peña. **Jan:** DOE holds hearings on second Supplemental Draft EIS for WIPP in Carlsbad, Albuquerque, and Santa Fe, New Mexico. [D45] **Sep:** Final second Supplemental EIS on WIPP published. [D46]	● **1997 - May:** In letter to DOE secretary, EPA Administrator Browner decrees DOE application "complete"; this starts the 1-yr clock for review of CCA. **Jun:** Appeals Court in Washington rules meetings between EPA and DOE proper when one agency proposes regulations for another agency as required by Executive Order and says NM and TX "lawsuit is without basis". [F56] **Oct:** EPA issues draft rule to approve WIPP with conditions: requires use of panel seals used in PA; design requires QA for waste generators; lists requirements for using process knowledge to characterize wastes; requires schedule for installing passive controls; denies any protective credit for passive controls; and 120-day public comment period begins. [F54]	

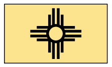
Compliance Evaluation

Test and Predisposal Phase

Clinton Administration

Johnson Administration

TRI-6342-6222-0

1998	**1998** EPA certifies WIPP		● **1998 - Jan:** DOE publishes record of decision to proceed with opening WIPP based on second Supplemental EIS. **Jul:** DOE Secretary: Richardson (former NM Congressman).	★ **1998 - May:** EPA certifies WIPP.[F53]	● **1998 - Jul:** NM AG Udall sues EPA alleging insufficient time to comment on CCA. CARD and SWRIC also file lawsuits.[N25]
1999	**1999** NMED grants RCRA permit 	● **1999 - Mar:** First shipment of non-RCRA waste arrives at WIPP from Los Alamos.[T142, T143] **Apr:** First shipment of non-RCRA waste arrives at WIPP from INEEL.[T145] **Jun:** First shipment of non-RCRA waste arrives at WIPP from Rocky Flats.[T146]	Clinton Administration	● **1999 - Mar:** Judge Penn lifts injunction placed on WIPP in 1992; also reverses decision and states WIPP does qualify for interim status under RCRA. **Jun:** Court of Appeals, District of Columbia, dismisses (without hearing oral arguments) CARD and SWRIC petition to overturn EPA certification.[F60]	★ **1999 - Feb & Mar:** NMED holds hearings in Santa Fe on RCRA permit for WIPP.[N26] **Apr:** NM AG Madrid withdraws from lawsuit challenging EPA certification.[N27] **Oct:** NM grants WIPP RCRA permit.[N28] Johnson Administration

TRI-6342-6223-0

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